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Publication date:
2024

Document Version
Publisher's PDF, also known as Version of record

Numerical investigations on gap resonances between side-by-side barges under wave-current conditions

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Ship-to-ship (STS) transfer of Liquified Natural Gas (LNG) has been commonly used to ensure high bunkering volumes and a stable supply of LNG to market. Likely, this technology will also be employed in the future to load/offload other green fuels. Fluid resonance, characterized by amplified oscillations of water in the gap and violent hydrodynamic forces on the adjacent vessels when the wave frequency approaches the natural frequency of the gap flow, poses a key challenge in the design and operation of those offshore structures. The presence of a current further complicates the involved key physics by affecting the amplitudes and frequencies of the waves. Currently, there are no studies at all in the works of literature that consider the three-dimensional (3D) gap resonances with current effects. Also, the influences of wave-current coupling on the gap resonances and the associated hydrodynamic loads have not been fully understood, which however seems to be important based on our recent studies in two dimensions [1].

This study focuses on the numerical investigation of 3D gap resonance between two side-by-side barges under combined wave and current conditions. A validated numerical wave tank based on the Reynolds-Averaged Navier-Stokes (RANS) equations, coupled with the Volume of Fluid (VOF) method, is employed based on the commercial CFD package STARCCM+. User-defined wave elevation and velocity, theoretically obtained from the stream function method, are applied within the forcing zones at inlet and outlet boundaries, respectively.

The effect of a uniform current, in the same direction as wave propagation, on the wave-induced gap response is systematically investigated by comparison with the cases without current. Both head- and beam-sea conditions are considered in the study, highlighting the three-dimensionality of this phenomenon and emphasizing the importance of accounting for lateral and vertical modes of gap response. This research enhances our understanding of the complex hydrodynamic interactions between side-by-side barges under wave-current conditions, providing valuable insights into improving the safety of side-by-side marine operations in real-sea environments.

References:

1. Ding Y., Walther J. H., Shao Y. (2023), Effect of wave-current interaction on gap resonance between side-by-side barges, under review.